ADAPTING FOREST PLANNING DECISION SUPPORT SYSTEMS FOR PRESCRIBED FIRE TREATMENTS

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ABSTRACT

Incorporating prescribed fire and fuel treatments into land management planning may require modification of computer-based forest planning decision support systems. A mail survey of USDA Forest Service fire management officers in the western US was used to identify key goals, constraints, and planning assumptions used in locating prescribed fires. Decision support systems may need to be modified to allow flexible treatment boundaries, increased temporal resolution, evaluation of wildlife habitat effects, analysis of short-term costs, and improved integration with fire and fuel models.

Keywords: GIS, landscape planning, tactical planning, prescribed burning

INTRODUCTION

Numerous models, including smoke models, fuel models, fire behavior models, and fire suppression models, exist to help fire managers make decisions about applying prescribed burning and fuel treatments. However, prescribed fire planning can only be based on understanding cumulative effects for ecological and socioeconomic processes if integrated into the general land management planning process. Fire managers and other managers within particular agencies, must also share common resources such as budget and personnel. Planning based on single-resource issues can prove costly, or, in some cases, infeasible.

The guiding principals of the federal wildland fire management policy and program review team suggest that fire management and the land management planning process must be integrated (USDI/USDA 1996). This paper looks at the problems associated with incorporating prescribed fire treatments into a class of computer models used for forest planning. Information on prescribed fire managers' goals, constraints, and planning methodology is drawn from the results of a 1997 survey of USDA Forest Service personnel.

FOREST PLANNING DECISION SUPPORT SYSTEMS

When the Committee of Scientists released their recommendations for revisions to rules for National Forest planning, they included an appendix on new computer models used for forest planning (COS 1999). Such models allow users to visualize desired future conditions for forest landscapes, and can help users choose the appropriate management actions to reach their goals. We refer to these as "forest planning decision support systems" (FPDSS) in this paper. FPDSS are generally designed to support management decisions about silvicultural treatments; with increased concern for integrating prescribed fire and fuel treatments into the general forest planning process, FPDSS may need modification.

Forest planning decision support systems include such models as ArcForest, ARGIS, IMPLAN, INFORMS, KLEMS, LANDIS, MAGIS, NED, RELMdss, SARA, SIMPPLLE, SNAP, SPECTRUM, TEAMS, TerraVision, UTOOLS, Woodstock and others (Mowrer 1997). Although all FPDSS are intended to aid forest management planning, they differ widely in specifics. In general, most share the following traits:

- Vegetation change can be projected for a landscape over a planning horizon.
- The spatial resolution of this change is set by polygons, which may be based on "patches", "stands" or "management units."
- The temporal resolution of this change is set by discrete time periods, to provide "snapshots" of future landscapes.
- The systems have direct or indirect linkages to GIS.
- The systems are used to analyze management options, with heavy emphasis on silvicultural treatments.
- Along with projecting vegetation change, the systems are often also used to analyze economic effects and commodity outputs.

In addition to the commonalties, systems have developed along different lines depending on the interests and intentions of the developers. ARGIS, for example, a system that runs on networked computers, is intended to facilitate small group interaction in collaborative planning situations (Faber et al. 1997). UTOOLS, which includes the Landscape Management System, allows 3-D visualization of stands and landscapes (Ager and McGaughey 1997). Carter et al. (1999) describe a FPDSS that allows Internet users to submit forest scenarios and retrieve graphical output over the Web.

FPDSS applications have also differed. MAGIS includes road-planning linkages and has been used to estimate sediment outputs (Zuuring et al. 1995). SNAP has been linked to stream and hydrological modeling (Sessions et al. 1997). SIMPPLLE is a stochastic model, with projections for natural disturbance events such as insect outbreaks and fire (Chew 1997). Many of the systems - SPECTRUM, MAGIS and SNAP, for example - include linear optimization options.

Typically, in most of the FPDSS, prescribed fire is implemented similarly to a silvicultural treatment. Whether FPDSS can adequately include prescribed fire as a management option will depend on how well the assumptions made in building a FPDSS model are met in prescribed fire planning. To understand the objectives and constraints of prescribed fire planning, we surveyed those who do it.

SURVEY

Names and addresses of Forest Service personnel associated with planning fuel treatments and prescribed fire were obtained from regional directories and phone calls. Surveys were sent to 399 individuals in the six western regions, and the usable response rate was 69%.

The majority of respondents were district, zone, or forest fire management officers (FMOs). Most individuals worked at the district level (56%) or at the zone (multiple district) level (23%) within a forest. Most individuals worked in short-interval fire regime areas (32%) or mixed-interval fire regimes (54%), with relatively few (12%) in long-interval fire regime areas.

Flexible Treatment Boundaries

Most FPDSS apply treatments to polygons, which are often based on stand or patch boundaries. Most planning models assume that polygon boundaries stay fixed throughout the planning horizon. Splitting or merging polygons is possible in any FPDSS, but it can be awkward and time-consuming. Changing polygon shapes is particularly problematic if the FPDSS is built to encompass road-access considerations, adjacency constraints, or spatial assignment algorithms. Applying the same treatment to groups of spatially congruent polygons may be possible in a FPDSS, but building in such coordinated choices can also be a time-consuming process. Because all model outputs can be affected by the choice of the initial polygons, there was some concern about how well prescribed fire and fuel treatments corresponded with polygon boundaries derived from stand-mapping.

Of those responding, 51% said that for their most recent prescribed burn, the boundaries of the area treated did not correspond well with stand boundaries as determined by their forest's mapping system. The size of the last area treated averaged 465 hectares, with planners from short-interval fire regimes treating larger areas.

The large size of treatment areas results in treatment areas that often consist of multiple stands rather than a single stand; 84% of respondents said that this was the case for the last area they treated. For their last prescribed burn, 8% of respondents said that the final perimeter was significantly different from where they had intended it to be.

These results indicate that FPDSS could best integrate prescribed fire treatments into the forest planning process if the user-interface facilitates polygon splitting, merging, and grouping.

The survey asked respondents whether the area chosen for their last prescribed burn had been chosen because of its proximity to other treated areas (for example, if it formed part of a larger buffer zone); 39% of respondents replied "yes" to this question. FPDSS that allow users to see information on past treatments would appear to be useful.

Temporal Resolution

FPDSS generally use planning periods of 5, 10, or 20 years to create "snapshots" of future landscapes. Many of these systems incorporate linear programming, goal programming, dynamic programming, or heuristic routines to solve the complex scheduling problems associated with silvicultural treatments and roading activities.

The survey asked respondents when they would reburn the last area treated. Some 15% of respondents were unsure, and 11% of respondents did not plan to re-burn that area. These percentages were higher for managers from areas with long-interval fire regimes. Of those who gave an interval for time to reburning, the average interval midpoints were:

19%	0 – 5	years
42%	6 – 10	years
29%	11 – 15	years
10%	15 +	years

The difference between high and low estimates for the reburning interval was, on average, 4 years.

The frequency with which short-interval reburning occurs suggest that FPDSS would be best suited to wide applicability for prescribed fire scheduling if a five-year (or shorter) planning period is used. Given the uncertainty about reburning and reburning intervals, models with at least several options for treatment intervals would have the greatest flexibility in meeting temporal constraints.

Limits to Prescribed Burning

On average, over the last three years, annual acres burned by respondents' districts was 681 hectares. (This represents the average for managers, not the average for Forest Service land). Respondents were asked how large an area they would like to treat the next year, if they had no resource constraints. On average, respondents wished to increase the area treated by twelve times past levels.

The survey asked people to give the "most important reason" for why they were unable to burn where they wanted the last time they experienced this. In general, weather windows and smoke constraints were cited most frequently (Table 1).

Table 1.

Reason given	N	Percent
Weather / time window for burning	108	39.0%
Smoke / airshed constraints	50	18.1%
Wildlife or T/E species	18	6.5%
Other resource conflicts	16	5.8%
NEPA / planning constraints	14	5.1%
Lack of personnel at burn time	13	4.7%
Funding	13	4.7%
Internal / external politics	12	4.3%
Unable to meet prescription	6	2.2%
Have never experienced this	5	1.8%
Firefighter safety concerns	3	1.1%
Other	8	2.9%
No response	11	4.0%

A second question also asked about constraints to prescribed burning, by asking that individuals rate preselected factors using a 5 point Likert scale. Factors rated as "influential" or "very influential" by a majority of managers included available time windows for burning, money available for treatments, and staff available for burning. Public opposition to smoke was rated as less influential than airshed restrictions. Public opposition to aesthetics was rated as comparatively uninfluential, as was lack of support from others in the district, forest, region, or the Washington office.

Typical constraints in a FPDSS are land area constraints, land-use constraints, timber volume sustainability constraints, budget constraints, and implicit constraints formed by initial vegetation and physiological conditions, availability of prescriptions, and natural processes such as succession and disturbance.

Incorporating smoke and airshed constraints in such models is possible, but acceptable accuracy may be difficult to achieve.

First, high-resolution fuels data, in a form compatible with smoke models, may not be available for landscapes of 10,000 to 100,000 acres. Second, prediction of the number of days with suitable weather conditions will be difficult, even when aggregated to five-year periods. Third, airsheds are common resources, and planners will face the difficulty of trying to guess what their neighbors will be doing and how that will affect their own burning opportunities. Fourth, public reaction to smoke from increased prescribed burning is an unknown factor. Fifth, wildfire also contributes to smoke conditions, and thus contributes to the difficulty of planning.

In spite of these difficulties, it is clear that prescribed fire managers are constrained to levels of burning that are a small fraction of what they would prefer to do. Thus FPDSS need to incorporate some type of constraint on prescribed burning, even if it takes the simple form of total land area burned per five-year time period.

Aesthetics and Conflict Resolution

Many of the most interesting developments in FPDSS in recent years have been centered around issues of conflict resolution, including systems that allow networked planning, web-based scenario creation, and stand and landscape visualization. However, institutional and public conflict appears to be less constraining for prescribed burning than for silvicultural treatments.

Public opposition and agency conflict were rated relatively low for constraints, and the mean score for "aesthetics" was 11th (out of 16 factors) in importance for locating prescribed burning. While 3-D visualization programs may still become widely used by prescribed fire managers, they probably will not result in significant relaxation of current constraints to prescribed burning programs.

Economics

Individuals were asked to estimate the source of funding, by percentage, for the total costs of their previous year's prescribed burning program. For the pre-selected categories, average estimates by district or zone managers were:

%	SOURCE
9%	non-essential Knutson-Vandenburg
67%	fuels treatment
4%	range betterment fund
20%	other

These figures represent funding as experienced by the average planner surveyed, rather than the relative dollar amounts in Forest Service accounts for that year. The Knutson-Vandenburg funding is derived from timber sales, while the fuels treatment category is appropriated. The "other" category included sources such as state fish and game departments, private contributions, brush disposal funds, and wildlife-related groups. The Rocky Mountain Elk Foundation was the organization most frequently listed as a funding source, with 16% of all respondents listing it as a funding source.

The mean score for "future economic returns" was 13th (out of 16 factors) in importance for locating prescribed burns, although the mean score for "cost of prescribed burns" was 6th. This suggests that developers of FPDSS would do better to support detail and sensitivity analysis for short-term costs rather than long-term economics. For larger land areas, the Forest Service may need to use economic analysis to aid in setting the appropriate level of prescribed burning. However, at the district level, managers experience budgets as a constraint on the level of prescribed burning that they would like to accomplish. Thus FPDSS will most likely be used to decide where (and when) to place treatments, rather than how much land should be treated.

Compatible Land Classification Systems

When survey respondents were asked to give the three most important factors in locating a prescribed burn, the five factors listed most frequently were: (1) general stand condition, (2) damage or loss if a fire occurs, (3) wildlife habitat; (4) probability of a fire start; and (5) the cost of the prescribed burn.

Wildlife habitat was listed as an important factor in locating treatments, was experienced as a constraint more often than all other resource conflicts (Table 1), and was an important source of external funds. Thus land classification systems used by FPDSS that include prescribed burning treatments may need to be compatible with wildlife habitat suitability models. Most FPDSS are general modeling systems, and can work with any single land classification system. However, integrating systems suitable to both wildlife habitat projection and fire/smoke/fuel models (see below) may eventually require the ability to track projected changes for multiple land classifications.

Compatibility with Fire / Fuel Models

FPDSS are often directed toward planning for landscapes of thousands or tens of thousands of hectares over planning horizons of 20 to 200 years. Although a few landscape fire models, such as FARSITE (Finney 1998), have been developed in recent years, most fire, fuel and smoke models operate on finer spatial and temporal scales than do FPDSS. However, for hierarchical levels of planning to be compatible, FPDSS should include realistic assumptions about which areas are suitable for prescribed burning, and how much burning can be accomplished given resource constraints.

Survey respondents were asked to list which fire/fuel models they used in planning prescribed fire. Particular models listed by more than 10% of respondents included: BEHAVE (85.2%); FOFEM (29.2%); FARSITE (26.4%); SASEM (26.4%) and PUFF (11.2%). Although compatibility of FPDSS with these and other models would be ideal, lack of detailed fuels data for landscapes is problematic.

GIS Training and Experience

The average age of survey respondents was 45 years, and the average time working in fire management was 19 years. As a relatively new technology, one might expect that fire managers have had little opportunity for GIS training. However, 70% reported some training in GIS. Unfortunately, we were unable to tell from survey results whether the training involved GIS education, or simple training on particular software systems.

Use of GIS within the past year (47% of individuals) was less than the percentage with some GIS training. However, over 88% of individuals had made a request of another person to get GIS information in the past year, and people who had GIS training were more likely to have made such a request.

FPDSS are typically not user friendly. Use of such systems often requires attending training courses or getting help from system developers. We expect that the increasing computer sophistication of land managers, along with the maturation of FPDSS, may partially alleviate this. With the relatively high level of training and GIS access for Forest Service prescribed fire managers, FPDSS development could be appropriately be directed toward their use.

A district FMO would be more likely to be participating on an assessment/planning team than to be creating the landscape model used by the team. However, any projection of future conditions will be most likely to aid assessment when confidence in the model is shared by all involved. Thus a FPDSS that can be used by all team members, whether FMOs or wildlife specialists, could make the greatest contribution to decision support.

CONCLUSION

The recent review of Forest Service planning regulations by the Committee of Scientists puts forth a vision of planning tiered to (1) bioregional, (2) strategic, and (3) small landscape levels (COS 1999). GIS-based forest planning decision support systems are likely to be used for integrated assessment and planning at the small landscape levels. However, most such models have been built for silvicultural applications, and should be modified to incorporate prescribed fire treatments.

Our survey of prescribed fire managers suggests that some commonly used assumptions for FPDSS do not hold true for prescribed fire management. FPDSS that assume polygons based on stand boundaries will need alteration to match what prescribed fire managers are doing in the field. Specifically, FPDSS that allow easy splitting, merging, and grouping of polygons would be an improvement. Short intervals between repeat prescribed fire treatments suggest FPDSS with short planning periods (5 years rather than 10 years) are needed. Fire managers also face different constraints than silviculturists, in the form of smoke and weather limitations with inherent uncertainty.

Finally, those who implement prescribed fire programs apparently face less public and internal organizational conflict than do those who implement silvicultural treatments; while interactive FPDSS and 3-D visualization FPDSS may be useful to prescribed fire managers, such models may be of greatest benefit to those who implement combined treatments of prescribed fire and mechanical removal.

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